Volume 9
Number 103 *The use of starters in butter-making*
Article 1

August 2017

# The use of starters in butter-making

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BULLETIN 103 MARCH, 1909

# EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS

DAIRY SECTION

# THE USE OF STARTERS IN BUTTER-MAKING

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# The Use of Starters in Butter-Making

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The ripening of cream is essentially a bacteriological and chemical phenomenon. The main process in the ripening is the lactic acid fermentation. Although it has not been proved that the lactic acid fermentation is responsible for all the changes in cream ripening, it is so closely associated with them that in practice ripening is governed by controlling this fermentation. This is done by controlling the temperature and using starters.

A starter is a material containing bacteria, used to inoculate a dairy product. It may be employed to inoculate milk for cheese-making or cream for butter-making. The bacteria are presumably of a desirable kind and are present in great numbers. Whole milk, skim milk, butter-milk, cream, whey, and sugar solutions are used for growing the bacteria. The germs are usually lactic acid bacteria, but some cultures are said to contain flavor producing bacteria.

In practice two kinds of starters are used; the commercial and the natural. The commercial starters are pure cultures of bacteria prepared by bacteriological methods. They are put up in milk, milk sugar, beef broth, and other substances. Those in the dry form maintain their vitality longer. The milk cultures show their age or ripeness by the coagulation of the milk. They are sold in packages of one to several ounces and are a staple commodity, like yeast. The creameries usually order these cultures to be sent them periodically by mail.

There are two steps in the preparation of a commercial culture for use in the creamery: The "building up" and the "carrying on", or propagation. Directions for these are sent with the cultures. A great deal has been said and written about the kind of milk that is best for starters. In the earlier days many buttermakers preferred milk from fresh cows, or from cows getting good feed. The period of lactation can have only an indirect and unimportant effect on starters. The fitness of milk for starters depends upon the number and kind of bacteria that it contains. The fewer the numbers of bacteria, and especially of spores, the better the milk for starters. The presence of a few lactic acid bacteria in milk that is to be pasteurized is not a great defect because they are easily killed by pasteurization. The buttermaker has not the means of knowing what kind of bacteria the milk contains. A bacteriological analysis or a fermentation test would show this, but the results would come so late that they would not be applicable to the lot of milk that has been examined. These methods are of value in finding which patron's milk is best, but the quality of a patron's milk sometimes varies daily. The senses and judgment of the buttermaker are the most practical guides. The sweetest and cleanest milk is the best in the long run.

A natural starter is derived from a natural fermentation of milk. A very important step in the preparation of such starters is their selection. The most conspicuous characteristic of a natural starter is the lactic acid fermentation. There is no way for ascertaining immediately whether a given lot of milk will develop a good lactic acid fermentation. It is thought that clean, sweet milk is more likely to produce the desired fermentation. But the lactic acid fermentation itself shows that milk was contaminated with bacteria. This self-same milk is not sweet when the fermentation has progressed far enough to "turn" the milk.

The obtaining of a good natural starter depends upon chance as well as judgment. Hence, the best method of selection is to take several small samples of milk, each sample from a different dairy, let them ferment at a temperature that is favorable to the lactic acid fermentation (60-75° F.), and examine them when they have coagulated. A good lactic fermentation produces a smooth curd free from gas, and there is no wheying off for a long time. Wheying off is usually associated with a bad flavor. The desirable flavor is best learned by experience. It should be acid, pleasant, and clean. A disagreeable odor is an undesirable quality but often a starter that makes good butter will show a stale or stuffy odor when it is ripened in a closed vessel. Although the logical test of a starter is to ripen cream with it and see what kind of butter it makes, experience soon teaches a buttermaker what starter makes the best butter so that he is soon able to judge a starter simply by sense tests. Having several samples of fermented milk or starters to choose from, the chances of getting a good starter are, of course, much better than where only one sample is taken. The variety affords comparisons and it is easier to judge the quality. When a good starter is found, it can be built up and carried on in the same manner as a commercial starter.

The relative merits of skim milk and whole milk for carrying on starters are points of controversy. Theoretically, whole milk is not as good because its fat does not afford any food for the bacteria. It is generally admitted that it is better to select the milk instead of taking some of the mixed milk. If the benefit of the selection is to be realized, the milk should be skimmed separately and handled in clean utensils. This involves a great deal of extra work. Moreover, the fat in the whole milk does not interfere with the growth of the bacteria. In the cream the bacteria have to grow in the presence of much greater quantities of fat. The fat, however, cloys the sense of taste and makes it somewhat more difficult to judge the quality of the flavor.

In pasteurizing milk for starters it is best to apply the heat for thirty to sixty minutes. A temperature of 150° F. kills all the sporeless bacteria. Higher temperatures, up to 212° F., do not kill the spores, but they are so weakened by the higher heat that they germinate more slowly and their harmful effect is retarded. This fact, and the results of experience, indicate a temperature of about 185 to 200° F. as best. The heating and cooling can be done in cans immersed in water. Stirring hastens the processes, but is not necessary when the heating surface is not hotter than about 200° F. Where the heating is done by steam, stirring is necessary to prevent scorching. Starter cans are a great convenience.

The building up of a starter consists in adding a culture to a quantity of pasteurized milk and ripening it. Then it is inoculated into a still larger quantity of milk and so on until the desired amount is obtained. The best results are obtained when the quantity of milk used for a culture is such that it is ripened in forty-eight hours or less; twenty-four hours is still better. When the fermentation has once developed in milk it grows more vigorously and gives the best results when the ripening period is not over twenty-four hours. When the quantity of milk inoculated is so large that it takes more than twenty-four hours to ripen, the spores that withstood the pasteurization and the bacteria that may accidentally get in, have a better chance to develop. Pasteurized milk, if kept long enough, will ferment and its flavors are usually bad. About one-third to one pint of milk is sufficient for most cultures. Glass jars, enameled ware, china, earthenware, and tin, are the best utensils for this purpose.

The lactic acid bacteria grow the most rapidly at 95 to 108° F. But in impure cultures, like a starter or milk, there are bacteria that can compete more successfully with the lactic acid fermentation at high or low temperatures than at mean temperatures. Thus at high temperatures stale flavors and gassy fermentations are frequent and it is difficult to avoid over-ripening. Bitter and other undesirable flavors are common at low temperatures. It is possible to ripen successfully at 55 to 90°, but the best flavor is developed at 60 to 75° F. It is better to ripen a culture that has just been inoculated in milk, at higher temperatures, because otherwise the ripening would be too slow.

When the starter has been built up to the desired quantity it is carried on, or propagated, from day to day. When a ripe starter is to be added to the cream or used for inoculation, it is best to skim off the top to a depth of about one inch. The top always has a poorer flavor due perhaps to the contamination from the air and the influence of the air itself especially on the growth of fungi like *Oidium lactis*. These skimmings can be added to the cream and need not be wasted, but their removal before taking some of the starter for an inoculation helps to maintain its good qualities. In this manner the poorer portion is not used for propagation, on the same principle that poor seed corn is discarded. The pasteurized milk is inoculated with such a quantity of the mature starter as will ripen the milk by the time it is to be used, usually twenty-four hours. An inoculation of two per cent generally accomplishes this. The length of ripening can also be controlled by the temperature. But ripening at a very high or very low temperature is likely to produce bad flavors. If it is desired to retard the ripening it is better to lower the temperature a little rather than to reduce the inoculation too much. Reducing the inoculation favors the competing bacteria.

The quality of a starter should always be examined before it is used for inoculating or before it is added to the cream. At any time it is likely to get so bad that it may do more harm than good and then it is not worth carrying on. In such a case the maker has to resort to a new culture or a new starter. For this emergency it is well to save out a quart or so of a good starter and keep it cold. A good starter kept at a low temperature will retain its good quality for a week or so. This reserve starter can be built up much more quickly than a commercial culture.

A starter sometimes gets so bad in a few days that it is not fit to use; in other cases it remains good for many months. The maintenance of its good quality depends upon the skill of the maker and the bacteriological quality of the milk.

A starter is in the bset condition to use when it contains the greatest number of the desirable bacteria. This occurs about the time that it coagulates. It then contains from five million to two billion bacteria per cubic centimeter. For several days after this the bacteria do not decrease very much and it would not be unfit on this point. If it is kept at a ripening temperature after it has coagulated bad flavors appear in the course of time. This is called over-ripening. It is not due to an excess of lactic acid but to the development of other bacteria that produces bad flavors. *Oidium lactis* is also associated with the bacteria in the production of ill flavors. Over-ripening occurs much more slowly at low temperatures. If the starter can not be used soon after it is ripe it is best to cool it as low as possible.

There are conditions where milk is received only every other day. In such cases it has been recommended to make up only a small quantity of starter the first day, save some pasteurized milk, re-pasteurize, and inoculate it the next day. This is hardly necessary. The ripening can be managed so as to take two days or the starter can be allowed to ripen and then cooled. The latter method is best because the combined effect of the low temperature and large amount of lactic acid retards the action of undesirable bacteria. Stirring the starter during ripening keeps the temperature more uniform but it has little value and is not practiced much. Some stir at the time of coagulation to prevent clotting. Stirring after it has coagulated will not cause wheying off unless the temperature is high or the flavor is bad.

A starter has the best opportunity for exerting its effect when it is put in the vat before the cream is put in. Some pour the starter into the vat through a strainer to break up the clots of curd which have a tendency to settle to the bottom of the vat. In practice the buttermakers use from a few per cent to 50 per cent of starter. Less than 2 per cent has very little effect unless the cream is sweet or pasteurized. More than 25 per cent involves the handling of so much material that it is impractical in a large creamery. From 10 to 20 per cent are good amounts for ordinary purposes.

Adding a large quantity of starter to bad cream and churning immediately improves the flavor of the butter. Washing bad butter in the granular form with a starter also improves it. This method has a great deal of promise. Starters are used in the manufacture of process butter and oleomargarine.

The commercial starters are likely to give better results in the hands of an unskilled maker. The right kind of bacteria have been selected for him and the rest of the work is more mechanical. A good maker can select a natural starter that is just as good as the best commercial starter. Circumstances sometimes make this difficult or impossible, so that commercial starter has the advantage of uniformity and reliability. However, some commercial startsrs cometimes fail in quality. Any starter is likely to get bad at any time. Success with all starters depends very much upon the skill and judgment of the maker.

Buttermilk or cream are sometimes used as starters. They hasten the ripening but they cannot make the product any better than the original cream. They may act as a catch-all for all the taints that come in the cream and a trouble occurring in one day's cream is likely to be carried from day to day. There is no chance of improvement above the general average.

The advantages and disadvantages of using starters in butter-making were under discussion for a long time. Today practically all butter-makers appreciate their value and almost all the large creameries use them. It is an open question whether it would pay to use a starter in making butter on a small farm. In such a case, the value of the time it takes to prepare a starter is too great in proportion to the total value of the butter.

## EXPERIMENTS WITH STARTERS

During the last four years we have carried on experiments with starters. Some portions of these experiments have been concluded, but others are less complete. We publish the complete experiments and such other results as might be of practical or theoretical value.

Many of the creameries are situated in large cities where milk is dear. It is sometimes difficult to obtain and sometimes it is unsuitable for starters. This causes the need of some cheaper medium for growing starters.

### FUNCTION OF SUGAR

The main chemical product in a starter is the lactic acid which is produced from milk sugar. Hence sugar is the chief food. This suggested the possibility of growing starters in sugar solutions. A great number of carbohydrates are fermentable into lactic acid.

For practical purposes the suitability of a solution for growing starters can be determined by the acidity developed in the solution and by its power to ripen cream and produce a good flavor in butter.

The solutions used in these experiments were put up in quantities of 100 cc in flasks, pasteurized, inoculated with a starter at the rate of 2 per cent, and ripened at about 70° F. unless otherwise stated.

### TABLE I

MILK DILUTED WITH WATER

*Acidity in per cent.*

| | 0 Hrs. | 18 Hrs. | 24 Hrs. | 40 Hrs. |
|---|---|---|---|---|
| 20% Milk.......... | .054 | .24 | .216 | .198 |
| 30% " .......... | .054 | .288 | .270 | .252 |
| 40% " .......... | .045 | .352 | .303 | .324 |
| 60% " .......... | .054 | .486 | .45 | .459 |
| 80% " .......... | .09 | .54 | .576 | .594 |
| 100% " .......... | .108 | .612 | .684 | .738 |

Table I shows that the greater the amount of water in milk, the lower the acidity. This is due to the decrease of sugar or protein.

Different amounts of milk sugar, brown sugar, and glucose were added to milk diluted to 60 per cent. The results were practically the same and are typified by milk sugar in Table II.

## TABLE II

60 PER CENT MILK, 40 PER CENT WATER, PLUS MILK SUGAR

*Acidity in per cent.*

| | 0 Hrs. | 24 Hrs. |
|---|---|---|
| 1% Milk Sugar............. | .072 | .432 |
| 2% " " ............. | .072 | .432 |
| 3% " " ............. | .054 | .34 |
| 4% " " ............. | .072 | .432 |
| 5% " " ............. | .072 | .432 |

The amount of acid produced was so small that a small amount of sugar is sufficient for its production. Table III further shows that the acidity decreases as the amount of water is increased.

## TABLE III

A mixture of whole milk, tap water, 4 per cent glucose, 100 cc in all, was pasteurized at 180° F. for thirty minutes and inoculated with 2 per cent of a lactic acid starter.

*Acidity in per cent.*

| | 0 Hrs. | 6 Hrs. | 19 Hrs. | 46 Hrs. |
|---|---|---|---|---|
| 10% Milk.......... | .018 | .14 | .18 | .16 |
| 30% " ......... | .018 | .30 | .40 | .34 |
| 50% " ......... | .018 | .49 | .54 | .54 |
| 70% " ......... | .018 | .50 | .74 | .59 |
| 100% " ......... | .018 | .52 | .77 | .76 |

### FUNCTION OF PROTEIN

To ascertain the function of casein some milk was treated with rennet, starters were grown in the milk, the whey, and a mixture of the whey and ground casein. The acidities were: Milk, 83 per cent, whey and curd, 57 per cent, and whey, 45 per cent.

The albumin and small particles of casein remained in the whey. To get rid of these the following process was used:

1. The casein in 100 cc of milk was precipitated with rennet. The whey was acidified with hydrochloric acid and heated in an autoclave at 115° C. for a few minutes. Then the whey was neutralized and the casein ground up in a mortar and returned to the whey.

2. The casein was precipitated with rennet and handled the same as No. 1, but the whey was filtered and the casein was not returned.

3. The casein was precipitated with hydrochloric acid and handled the same as No. 3.

4. Whole milk.

The results are shown in the following table:

TABLE V

*Acidity in per cent.*

| No. | 24 Hrs. | 48 Hrs. |
|---|---|---|
| 1 | .56% | .59% |
| 2 | .25 | .36 |
| 3 | .27 | .36 |
| 4 | .74 | .74 |

The whey produced about the same acidity (.36 per cent) as the sugar solutions containing 5 to 10 per cent milk (.2-.3 per cent). But the whey and curd producced nearly as much acid (.59 per cent) as the milk (.74 per cent). Therefore the casein favors the development of acid.

An investigation was made to ascertain whether casein serves as a source of protein or as a base for neutralizing the acid.

Some starter was neutralized with sodium hydroxide, sterilized, and inoculated. The acidity was in 17 hours .49 per cent; in 65 hours .83 per cent.

Starters were grown in the following solutions:

| | | | | |
|---|---|---|---|---|
| No. 1. | 50 cc Water, | | 2.5 Grams Chalk, | .5 grams peptone |
| 2. | 50 cc Water, | 2 grams Glucose, | 2.5 Grams Chalk, | .5 grams peptone |
| 3. | 50 cc Water, | 2 grams Glucose, | 2.5 Grams Chalk, | .5 grams peptone |
| 4. | 47½ cc Water, | 2 grams Glucose, | 2.5 cc Milk, | .5 grams peptone |
| 5. | 47½ cc Water, | 2 grams Glucose, | 2.5 cc Milk, | 2.5 Grams Chalk |

The precipitated chalk was used for a base, the peptone as a supply of nutritive protein, the glucose as a source for the acid, and the milk as a source of base and protein.

The titration of the chalk mixtures gave difficulties at first, because the chalk combines very slowly with a weak acid. This difficulty was overcome by preparing a number of flasks of the solution and using a whole flask for the titration. One flask received 26 cc of approximately double normal hydrochloric acid, was boiled, and titrated with a standard alkali, using phenolphthalien as an indicator. When the gain in acidity in another flask was to be determined this procedure was repeated and the difference between this titration and the blank was the gain in acid.

The averages of three such experiments follow:

TABLE VI.

*Acidity in per cent.*

| | 24 Hrs. | 48 Hrs. | |
|---|---|---|---|
| No. 1 | .15 | 0 | Chalk, peptone, and glucose |
| 2 | .49 | .86 | Chalk, peptone and glucose |
| 3 | .14 | .20 | Peptone and glucose |
| 4 | .15 | .15 | Glucose, milk, and peptone |
| 5 | .70 | .84 | Glucose, milk, and chalk |

The acidity was low where sugar was lacking (1) and where a base was lacking (3 and 4). It was as high as in milk where a base, sugar, and protein were present (2 and 5); 2.5 cc (5 per cent) of milk was sufficient as a source of protein, but not as a base. The same is true of .5 gram (1 per cent) of peptone.

The lactic fermentation is retarded by .1 per cent free lactic acid and arrested by .15 per cent of acid. "Larger quantities of acid are produced only where some basic substance is present."* The casein of sweet milk fulfills this office.

The use of chalk in deep vessels of starter is not feasible because it settles to the bottom. Theoretically bicarbonate of soda seemed better suited.

To a mixture of 5 per cent milk, 4 per cent glucose and 91 per cent water the following percentages of bicarbonate of soda were added: .1 per cent, .2 per cent, .4 per cent, 1 per cent, 1.4 per cent and 2 per cent. This was tried eleven times. One of the tables is selected to represent the results.

TABLE VII

*Acidity in per cent.*

| Amt. of NaHCO3 | 24 Hrs. | 48 Hrs. | 72 Hrs. | 96 Hrs. | 120 Hrs. |
|---|---|---|---|---|---|
| .05% | .171 | .180 | .144 | .209 | .243 |
| .1 % | .180 | .180 | .171 | .216 | .270 |
| .2 % | .171 | .180 | .207 | .234 | .270 |
| .5 % | .054 | .180 | .468 | .468 | .495 |
| .7 % | .117 | .198 | .162 | .306 | .432 |
| 1.0 % | .396 | .522 | | | .594 |

The largest amount of acid produced (.594 per cent) is much less than in the chalk mixture (.84 per cent) or in milk (.8 to 1.0 per cent).

In the same kind of solution potassium hydrogen phosphate ($K_2HPO_4$) was substituted for the bicarbonate of soda to test

*Hayduck Chem. Cent. 1887 p. 1042.

the effect of a phosphate. Six trials gave no more acid than was usually developed in the same mixture without the phosphate. Glucose solutions containing small quantities of sodium hydroxide did not favor the development of acid.

Two counts of bacteria were made of the solutions containing large and small amounts of acid at an age of 24 hours. The average follows:

TABLE VIII

| | | |
|---|---|---|
| Water-chalk-peptone | Acid .18% | Bacteria 179,000,000 |
| Glucose-chalk-peptone | Acid .66% | Bacteria 580,000,000 |

The results are the same as occur in milk. The numbers of lactic acid bacteria increase with the acidity till the acid begins to retard their growth. Where a small amount of acid is developed the numbers of bacteria are also small.

PRACTICAL TEST.

A quantity of cream was divided into halves, 10 per cent glucose starter (5 per cent milk, 4 per cent glucose, 91 per cent water) added to one half, and 10 per cent of milk starter added to the other. In the first lot on Table IX, 30 per cent of starter was used and this lot and the first lot in the bad cream series were cooled and churned without ripening. The other lots were pasteurized, ripened and churned. The butter was scored by Professor McKay. Due to the low acidity and germ content of the glucose starters the cream in which they were used ripened very slowly and usually could not be ripened to the same acidity as the other cream. The results are given in Table IX.

TABLE IX

SWEET CREAM.

| MILK STARTERS. | | | | GLUCOSE STARTERS. | | | |
|---|---|---|---|---|---|---|---|
| Acidity of Starter | Hrs. Cream Ripened | Acidity of Cream | Score of Butter | Acidity of Starter | Hrs. Cream Ripened | Acidity of Cream | Score of Butter |
| 1.0% | 0 | .50 | 94 | .26% | 0 | .20% | 93¾ |
| 1.0 | 6 | .61 | 93¾ | .13 | 20 | .52 | 94 |
| | 8 | .65 | 95 | | 19 | .54 | 94½ |
| 1.1 | 9 | .76 | 97 | .21 | 19 | .65 | 96 |
| 1.1 | 9 | .64 | 93½ | .20 | 20 | .57 | 93½ |
| | | | Averages. | | | | |
| 1.05 | | .63 | 94.65 | .20 | | .496 | 94.35 |
| BAD CREAM. | | | | | | | |
| 1.0 | 0 | .72 | 92½ | .23 | 0 | .56 | 92½ |
| 1.3 | 3 | .76 | 93 | .27 | 18 | .65 | 93 |
| 1.0 | 3 | .70 | 94½ | .22 | 18 | .70 | 94½ |
| | | | Averages. | | | | |
| 1.1 | | .73 | 93 1-3 | .24 | | .64 | 93 1-3 |

The low acidity of the glucose starters gives them weak tastes. They contain about as many bacteria as a milk starter and require from two to three times as much time to ripen cream. The flavor of the glucose starter butter is practically as good as that of milk starter butter. Reckoning milk at $2 a hundredweight and glucose at 10 cents a pound, the material for 100 pounds of glucose starter costs 50 cents.

### CONDENSED MILK STARTERS.

Some creameries prepare starters from bulk condensed skim milk. We tried condensed whole milk both sweetened and unsweetened. The best results were obtained by using one part of condensed milk and three or four parts of water. If the water used for diluting the condensed milk has been pasteurized it is not necessary to pasteurize the mixture.

At first it seemed that the sweetened condensed milk starters did not go off flavor as quickly as unsweetened milk starters. To investigate this, starters were propagated in common milk, common milk plus 5 per cent cane sugar, and common milk plus 2 per cent salt. The average of forty-two successive days of propagation are as follows:

TABLE X

| | Score | Acidity |
|---|---|---|
| Milk plus 5% Sugar.............. | 96.5 | .8376 |
| Milk plus 2% Salt............... | 96.68 | .8745 |
| Milk ........................... | 96.15 | .8958 |

The difference in score is too small to give a foundation for general conclusions. Salt or sugar might inhibit injurious fermentations or cloy the sense of taste, i. e., cover up bad flavors. If there is any effect it is of the latter kind. The starter containing the salt never coagulated, even though it sometimes contained 1.0 per cent of acid.

### CARRYING STARTERS IN PASTEURIZED AND STERILIZED MILK.

Many believe that starters would not go off flavor as easily if they were propagated in sterilized milk. We carried on starters for 35 days in the same milk pasteurized at 190° F. for 20 minutes and sterilized at 240° F. for 15 minutes, inoculating at the rate of 2 per cent. On the fifteenth day the flavor was the same in both milks so we reinoculated only every other day. On the twenty-seventh day the flavor was still good and unchanged so the starters were allowed to stand four days. They became bitter and then ropy. Now they were reinoculated every day for four days. By the end of this time they both had improved to such an extent that they were as good as on the start. The quality of the milk received at the creamery during this time was excellent and produced good starters in the factory. Had the milk been poorer it would have been a better experiment because then the sterilized milk may have given better results than the pasteurized. Hence the experiment is not conclusive.

The following are the averages of the scores and acidities.

TABLE XI

| | Score | Acidity |
|---|---|---|
| Pasteurized ..................... | 96.73 | .91 |
| Sterilized ....................... | 95.78 | .94 |

| % of Acid Producing | Number of Putrefactive | % of Putrefactive | Number of Oidium *lactis* | % of Oidium *lactis* |
|---|---|---|---|---|
| **99** | 10,000 | .33 | 0 | 0 |
| **99.9** | 600 | .0009 | 8,000 | .012 |
| **99.9** | 0 | 0 | 25,000 | .012 |
| **94** | 0 | 0 | 100,000 | .05 |
| **96** | 0 | 0 | 7,000,000 | 4. |
| **91** | 0 | 0 | 9,000,000 | 8. |
| **71** | 0 | 0 | 40,000,000 | 21. |
| **50** | 0 | 0 | 40,000,000 | 50. |

## OVER-RIPENING OF STARTERS AND CREAM.

Analyses of cream and starters at various ages were made as shown in Table XII, which is typical of two experiments. Before the significance of *Oidium lactis* was suspected four experiments were made in which no counts of Oidium were made.

TABLE XII

OVER-RIPENING IN CREAM.

The following determinations were made on a sample of fresh separator cream containing 28 per cent butterfat. It was kept at 60° F. to give a slow fermentation so it could be studied.

| Age Days | Acidity | Flavor | Odor | Total Number of Organisms | Number of Acid Producing |
|---|---|---|---|---|---|
| 0 | .1 | Very good | Very good | 2,962,000 | 2,940,000 |
| 1 | .2 | Very good | Very good | | |
| 2 | .42 | Very good | Very good | 64,008,600 | 64,000,000 |
| 3 | .43 | Very good | Very good | 200,025,000 | 200,000,000 |
| 5 | .45 | Stale | Stale | 170,100,000 | 170,000,000 |
| 7 | .45 | Stale | Stale | 187,000,000 | 180,000,000 |
| 9 | | Stale | Stale | 109,000,000 | 100,000,000 |
| 11 | .80 | Yeasty, Sour | Yeasty, Sour | 140,000,000 | 100,000,000 |
| 14 | .34 | Cheesy | Cheesy | 80,000,000 | 40,000,000 |
| 17 | | Cheesy | Cheesy | | |
| 19 | | | Putrid | | |

The lactic acid bacteria increased till .4 to .5 per cent of acid was reached, then they decreased. The putrefactive (liquefying) bacteria either decreased from the start or increased till .6 per cent of acid was present, when they decreased. When an acidity of .4 to .7 per cent was reached *Oidium lactis* became apparent. Then it grew to several millions when a white felting developed on the surface. As *Oidium* increased to great numbers the acidity diminished. Bad flavors and odors appeared at the time when *Oidium* reached great numbers. There is more direct relation between the bad flavors and the increase in *Oidium* than between bad flavors and numbers of putrefactive bacteria. The numbers of bacteria and *Oidium* are a very rough comparison because the separation and counting of *Oidium* is very difficult. *Oidium* cells are so much larger that they can not be considered equivalent to bacterial cells.

In neutralizing a starter with ammonia it was accidentally discovered that the so called "flat" flavor was produced. It was found that ammonium lactate has this flat flavor. The flat flavor is more frequently noticed in the earlier stages of ripening. It is probable that the putrefactive bacteria which are more numerous at the beginning than at any time later, produce ammonia which gives rise to ammonium lactate. The flat flavor is usually associated with wheying off. This phenomenon is undoubtedly caused by an enzyme acting upon the casein.

## SUMMARY.


1. Glucose starters produce as good flavor in butter as milk starters. The ripening of the cream requires two to three times as much time.
2. A suitable base and sugar and a small amount of protein are necessary for producing large amounts of lactic acid.
3. Condensed milk diluted with three to four parts of water produces good starters.
4. *Oidium lactis* is found on the surface of old milk and cream and is associated with over ripening.